CHAPTER IV
GROUND WATER QUALITY AND MANAGEMENT

Chapter IV discusses:

▸ Ground Water Quality in WMA 6 (Upper Passaic, Whippany and Rockaway Rivers).

▸ Ground Water Quality in WMA 19 as provided by the US Geological Survey (USGS).

▸ Planned improvements to the Ground Water Quality Monitoring Network.

Note: This chapter reflects changes and improvements to New Jersey's Ground Water Monitoring and Management Programs. Readers are referred to the ground water management program descriptions provided in the *1996 State Water Quality Inventory Report*.

The following ground water goal was developed through NEPPS, and is supported by objectives and indicators. Efforts are underway to develop ground water indicators, which will be reported in the 2000 Water Quality Inventory Report and through NEPPS reporting. It is expected that implementation of the redesigned Ambient Ground Water Quality Monitoring Network, described in this Chapter, will facilitate development of statewide indicators of ground water quality.

Ground Water Goal
To protect and enhance the quality of ground water and assure that adequate quantities of ground water will be available for domestic, municipal, industrial and other purposes as well as serving a vital role in maintaining aquatic ecology by providing ground water base flow to receiving waters.

Ground Water Quality in WMA 6

Significant portions of the water quality characterization presented here are based upon a ground water quality monitoring network which began in 1982 and was operated cooperatively by NJDEP and USGS until 1998. The goal of this network was to characterize natural ground water quality as a function of geology. Care was taken to avoid wells or groundwater that showed anthropogenic impacts in order that natural background conditions could be characterized. The network design did not identify trends or track pollution impacts. Therefore, in order to provide a comprehensive characterization of ground water in this region, the results of special investigations which examined anthropogenic pollution impacts are presented here as well as a supplement. The resulting characterization is based on 84 wells in WMA 6, including wells sampled in the NJDEP\USGS ground water quality monitoring network and wells sampled in special studies. Note that in order to better characterize the natural quality of waters in aquifers underlying WMA 6 it was necessary at times to consider results from wells from similar aquifers located outside

WMA 6.

Samples were analyzed for field parameters, major ions, nutrients, trace elements, and many were also analyzed for radioactivity and volatile organic compounds. Note that most data presented here were derived from filtered samples, so results characterize dissolved constituents, potentially underestimating total concentrations of parameters that adsorb onto mobile particles (e.g., trace elements). This must be kept in mind when comparing these data to Ground Water Quality Standards for Potable Supplies (i.e., Class IIA) and the NJ Drinking Water Quality Standards (DWQS) as these standards are based on whole water (i.e. unfiltered samples). Dissolved samples are analyzed so as to avoid the potential high bias produced when suspended particulates are introduced into the well during the sample collection process. Wells can vary with regards to the quantity of silt which can come up in the water sample. The network is designed to reflect the conditions in the ground water in the aquifer and not specifically the individual well that is being drawn from, hence, these particulates are filtered out. The results presented here are believed to closely reflect water quality which would be drawn from an active drinking water well. However, comparisons of whole water and filtered samples are needed to improve the utility of these filtered data and to draw precise conclusions regarding assessments based upon filtered samples and the applicability of these assessments to drinking waters (unfiltered) drawn from public and private wells.

The following ground water assessments are based upon comparisons with both New Jersey Ground Water Quality Standards and Drinking Water Quality Standards. In many cases the two are identical. When they are not, both criteria are used and this is has been noted in Table IV-1. Readers are referred to Table IV-1 for details regarding the specific criterion employed for each water quality constituent.
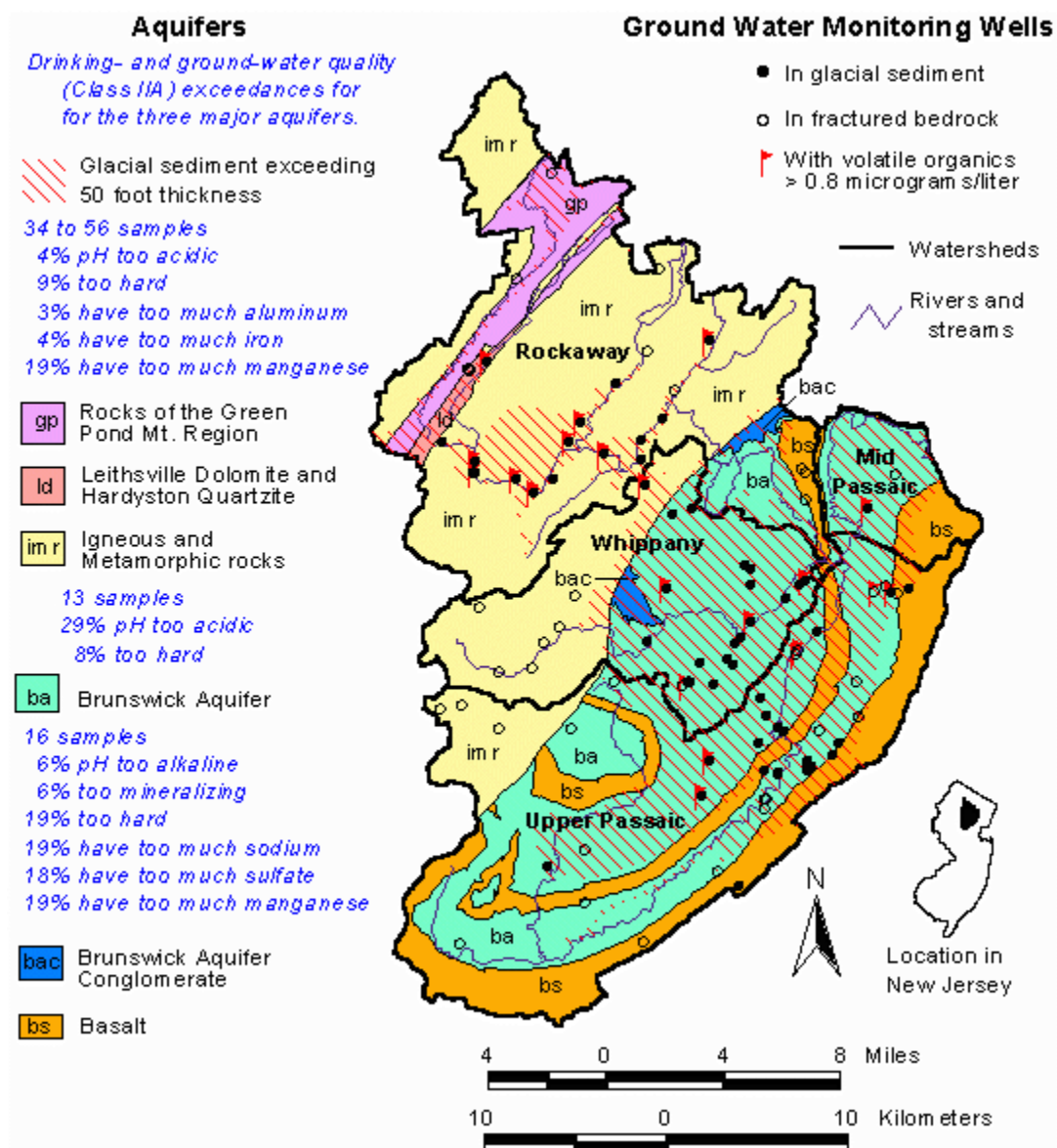
Two major aquifers types underlie WMA 6: valley fill and fractured bedrock aquifers. Valley fill aquifers were formed where sand and gravel were deposited during glacial events. These aquifers tend to have high water yields and are heavily utilized for water supplies. Fractured bedrock aquifers underlie all of WMA 6. Water is generally stored in small fractures in rocks. These aquifers tend to have a lower water storage capacity.

Results for Pleistocene glacial sediments (a valley fill aquifer) and Brunswick Aquifer and Igneous and Metamorphic Rocks (fractured bedrock aquifers) are provided on Table IV-1 and shown spatially on Figure IV-1. Based on this ground water quality data (Table IV-1), natural ground water quality in WMA 6 is good. The results do not indicate any significant natural quality issues related to potable use of ground water in the area. Primary drinking water quality standards for nitrate, toxic metals and gross alpha were not exceeded in samples taken from any aquifers in the DEP\USGS network in WMA 6. Ground water from the Pleistocene Glacial Sediment aquifers exhibited minor exceedences of less than 10% of observations for hardness, aluminum, iron and pH (all secondary drinking water standards). Moderate exceedences of 11% to 25% were observed for manganese. It must be noted that sampling procedures employed here may not reflect the influence of radium 224 in the total gross alpha particle activity analysis. New sampling protocols are now employed that do reflect the influence of all three isotopes of radium.

In the Brunswick Aquifer System, minor exceedances were observed for total dissolved solids and pH. Moderate exceedances of 19% were observed for hardness, manganese, and sodium, and 18% for sulfate. These data closely agree with data from 95 wells in this aquifer that are located outside of WMA 6. Data from Zapecza et. al. (1987) showed that the primary standard for gross alpha was exceeded in a small percentage of the wells in this aquifer. No exceedences of gross alpha were detected in the present study. Data from igneous and metamorphic rocks showed severe exceedences for low pH (29% of the samples exceeded the criterion) and minor exceedences for hardness (8% of the samples exceeded the criterion).

Wells with detectable concentrations (greater than 0.8 ug /l of VOCs) of volatile organic compounds are shown in Figure IV- 1. The presence of these compounds indicates that in some areas, particularly the glacial valley aquifers, ground water has been impacted by human inputs of these pollutants. An example of an area that is extensively polluted with VOCs is East Hanover Township, Morris County. Regional ground water contamination exists in the glacial valley aquifer system in this township (Oudijik, 1987). Contaminants are widespread and include VOCs, base neutral compounds, acid extractable organic compounds and petroleum hydrocarbons. The highest concentration of VOCs detected in this study was 16,690 ug/l. The cause of most of the contamination was widespread improper disposal of industrial waste. Sources included lagoons, industrial septic systems, buried drums, seepage pits and dry wells. Leaking underground storage tanks have also contributed to the pollution problem. Many wells used for municipal, domestic and industrial water supplies have been impacted. Pumping these wells has increased the spread of ground water contamination in the area. A well restriction area was delineated for the entire township.

As previously stated, the existing DEP/USGS ground water quality monitoring program was designed to characterize natural ground water quality as a function of geology in order to provide a basis to then evaluate less pristine areas. In so doing, however, known pollution sources were avoided for most of this data set, therefore the data do not provide an overview of the full range of ground water quality in the area. In response to this need, DEP and USGS recently began redesigning the ground water quality monitoring network. For further details see *A Proposed Redesign Of The Ground Water Monitoring Network* described later in the Chapter.

Aquifers

Drinking- and ground-water quality (Class IIA) exceedances for for the three major aquifers.

⧄ Glacial sediment exceeding 50 foot thickness

34 to 56 samples
 4% pH too acidic
 9% too hard
 3% have too much aluminum
 4% have too much iron
19% have too much manganese

gp Rocks of the Green Pond Mt. Region

ld Leithsville Dolomite and Hardyston Quartzite

im r Igneous and Metamorphic rocks

 13 samples
 29% pH too acidic
  8% too hard

ba Brunswick Aquifer

16 samples
 6% pH too alkaline
 6% too mineralizing
19% too hard
19% have too much sodium
18% have too much sulfate
19% have too much manganese

bac Brunswick Aquifer Conglomerate

bs Basalt

Ground Water Monitoring Wells

● In glacial sediment

○ In fractured bedrock

⚑ With volatile organics > 0.8 micrograms/liter

—— Watersheds

〰 Rivers and streams

Rockaway

Mid Passaic

Whippany

Upper Passaic

Location in New Jersey

N

| 4 | 0 | 4 | 8 | Miles |

| 10 | | 0 | | 10 | Kilometers |

Figure IV-1: Ground Water Quality in WMA #6 (from NJDEP, 1998)

Table IV-1: Ground Water Quality Standards and Ground Quality In Major Aquifers In WMA #6

Drinking Water Characteristic or Constituent (1)	Drinking Water or Ground Water Quality Standards (2, 3)	Pleistocene Glacial Sediments		Brunswick Aquifer System		Igneous and Metamorphic Rocks	
		Number of Samples	% exceeding Standards (4)	Number of Samples	% exceeding Standards	Number of Samples	% exceeding Standards
Characteristic							
pH	6.5 to 8.5 (s)	55	4<6.5, 0>8.5	16	0<6.5, 6>8.5	13	**29<6.5,0>8.5**
Solids, dissolved, mg/l	500 (s)	56	0	16	6	13	0
Hardness, (mg/L as CaCO3)	250 (s)	56	9	16	**19**	13	8
Dissolved Constituents							
Sodium	50 (s)	56	0	16	**19**	13	0
Chloride	250 (s)	56	0	16	0	13	0
Sulfate	250 (s)	56	0	16	**18**	13	0
Fluoride	2 (s), 4 (p)	56	0>2	15	0>2	13	8>2, 0>4
Nutrients, Dissolved (mg/L)							
Nitrogen, NO2, (as N)	1 (p)	34	0	11	0	13	0
Nitrogen, NO2+NO3, (as N)	10 (p)	34	0	10	0	13	0
Nitrate, [NO2+NO3] - [NO2]	10 (p)	34	0	11	0	13	0
Trace & Minor Dissolved Constituents (ug/L)							
Aluminum	200(s)	34	3	11	0	13	0
Antimony	6 (p)	15	0	9	0	0	0
	[2]	15	0	9	0	0	0
Arsenic	50 (p)	34	0	11	0	13	0
	[20]	34	0	11	0	13	0
Barium	2000 (p)	15	0	10	0	0	0
Beryllium	4 (p)	34	0	10	0	2	0
	[.008]	30	0	10	0	2	0
Cadmium	5 (p)	34	0	10	0	13	0
	[4]	34	0	10	0	13	0
Chromium	100 (p)	34	0	11	0	13	0

Drinking Water Characteristic or Constituent (1)	Drinking Water or Ground Water Quality Standards (2, 3)	Pleistocene Glacial Sediments		Brunswick Aquifer System		Igneous and Metamorphic Rocks	
		Number of Samples	% exceeding Standards (4)	Number of Samples	% exceeding Standards	Number of Samples	% exceeding Standards
Copper	1300 (al)	34	0	11	0	13	0
	[1000]	34	0	11	0	13	0
Iron	300(s)	55	4	11	0	13	0
Lead	15 (al)	34	0	11	0	13	0
	[5]	34	0	11	0	13	0
Manganese	50 (p)	56	**19**	16	**19**	13	0
Mercury	2 (p)	34	0	11	0	13	0
Silver [no GWQS]	100 (s)	15	0	10	0	0	0
Selenium	50 (p)	30	0	9	0	2	0
Zinc	5000 (p)	34	0	11	0	13	0
Radioactivity (pci/L)							
Gross Alpha	15 (p)	0	0	0	0	7	0

Notes:

1. Units: mg/l = milligram per liter (ppm); ug/l = microgram per liter (ppb); pci/l = picocuries per liter
2. Ground Water Quality Standards and Drinking Water Quality Standards identical except where noted in brackets [GWQS- Class IIA]
3. p/s/al: p = primary DWQS; s = secondary DWQS; al = GWQS action level
4. ---- = data are not available

Ground Water Quality In WMA #19

The USGS assessed ground water quality from samples collected by the DEP/USGS cooperative monitoring network within Water Quality Management Area 19 (Cooper/ Rancocas/Pennsauken Watersheds). Samples analyzed were collected between October 1996 and September 1997 from 22 shallow wells ranging from 10 to 85 feet in depth (USGS 1997). The wells sampled were selected by DEP to study the impacts of land use on shallow ground water near surface waterbodies. The USGS used 2 variables of ground water quality: nitrate plus nitrite nitrogen and volatile organic compounds (VOCs), of which a total of 29 VOCs were analyzed in their assessment. Seven different unconfined aquifer types, in 3 categories of land uses; urban, agricultural and undeveloped; were sampled in the study. The results are listed below.

▸   Nitrate plus nitrite nitrogen levels were measured in all 22 wells. Values range from below the laboratory reporting limit of 0.05 mg/l to a high of 9.9 mg/l. The high value is very close to the drinking water MCL of 10 mg/l. In general, nitrate+nitrite levels were lowest in the undeveloped land use areas, higher in the locations classified as agricultural or urban land use.

▸   Seventeen of the wells were analyzed for the presence of volatile organic compounds (VOCs). Seven wells, representing all three land uses, yielded positive results with levels either equal to or greater than the laboratory reporting limit of 0.2 ug/l. The most frequently encountered VOCs were chloroform and methyl tertiary butyl ether (MTBE); the highest concentrations of which were 1.0 ug/l and 5.4 ug/l, respectively. These levels do not approach the NJDEP surface water human health limit of 5.67 ug/l for chloroform, nor the NJ drinking water MCL limit of 70 ug/l for MTBE.

▸   Ground water quality is affected by overlying land use and the geologic material through which it flows.

▸   In some cases, nearby streams contributed water to the aquifer. In these locations, surface water quality would affect ground water quality.

The Department plans in the future to assess the ground water in this region in a manner similar to that performed on WMA 6, through the Watershed Characterization and Assessment Program.

Proposed Redesign of the Ground Water Monitoring Network

 Between 1982 and 1997, New Jersey's ground water monitoring was directed toward determining the natural quality of the state's ground water as a function of the surrounding geology. Known pollution sources were avoided and samples were analyzed for the presence of volatile organic compounds to further screen out wells affected by anthropogenic inputs. Twenty-two wells were sampled annually in one of the state's four physiographic provinces for dissolved

elements including metals, dissolved nutrients, volatile organic compounds (VOCs) and radioactivity (gross Alpha and Beta). Network data are available from the following sources: (1) the USGS computerized data system, WATSTORE, (2) EPA's computerized data system, STORET, (3) USGS's annual reports "Water Resources Data- New Jersey" and (4) the New Jersey Geological Survey.

Surveys of all four physiographic provinces have been completed, providing a statewide overview of natural ground water quality as a function of geology. As a new phase of ground water assessment to meet current and future information needs of the Department, the NJDEP and USGS are redesigning the ground-water quality monitoring network. Specifically, these proposed goals for the redesigned ground water network are to:

▸   assess shallow ground-water quality status;
▸   evaluate sources of ground water pollution associated with land-uses, and evaluate
        transfer relations such as correlating water quality to these land uses;
▸   assess trends in shallow ground-water quality;
▸   identify emerging issues before potable supplies or surface waters are negatively affected
        (e.g., pesticides and MTBE in ground water).

The proposed network redesign plan focuses on ground water samples collected from the shallow ground water table. Anthropogenic sources of pollution generally affect ground water at the water table first and most significantly. Since the hydraulic connection with the land surface is usually vertical, land use activities can generally be directly correlated to ground-water quality at the water table. Determining the exact recharge areas and time of travel for deeper wells is generally much more difficult and resource intensive. Therefore, the network will serve as an early warning system identifying emerging threats to ground water quality. Note that the network is not directly assessing drinking water supplies because ground water at the water table is generally not used for public or individual drinking water wells. However, what today is shallow ground water, might migrate in a number of years into deeper layers and could potentially become a future drinking water source. In addition, shallow ground water often feeds streams and wetlands, therefore, this network will facilitate evaluation of ground and surface water quality interactions.

Wells will be located using a stratified random design that directly considers land uses (i.e., agricultural, urban/suburban and undeveloped) and indirectly considers Watershed Management Areas and physiographic provinces. Well water samples will be analyzed for field parameters, major ions, nutrients, trace elements, radioactivity, volatile organic compounds and pesticides.

The plans for redesigning the network are expected to be completed in 1999. After review and approval, the redesigned network is expected to be implemented over a 5 year period in each of the 5 Water Management Regions. Each year, wells will be established, using existing wells or drilling new ones as needed.

Although still under discussion, a proposed statistical approach for determining the statewide

status of "water at the water table" could be determined by applying appropriate parametric and/or nonparametric statistical techniques to develop ground water quality indicators. A median value of an indicator would be calculated and confidence intervals (such as the 95 percent) can be determined using methods described in Spruill and Candela (1990).

An example of how an analysis might be performed for nitrate is as follows:

1. Determine the status (median) of nitrate concentration in each landuse (urban, agricultural, undeveloped).
2. Multiply medians for each land use by the percent area of that landuse in the state so that the state status value is weighted by land area.
3. Calculate weighted median concentration of nitrate in the state

Ground water indicators developed through this approach are expected to provide the first statewide estimates of ground water quality at the water table. These indicators can be used to target further site-specific evaluations and appropriate management measures.

LITERATURE CITED

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